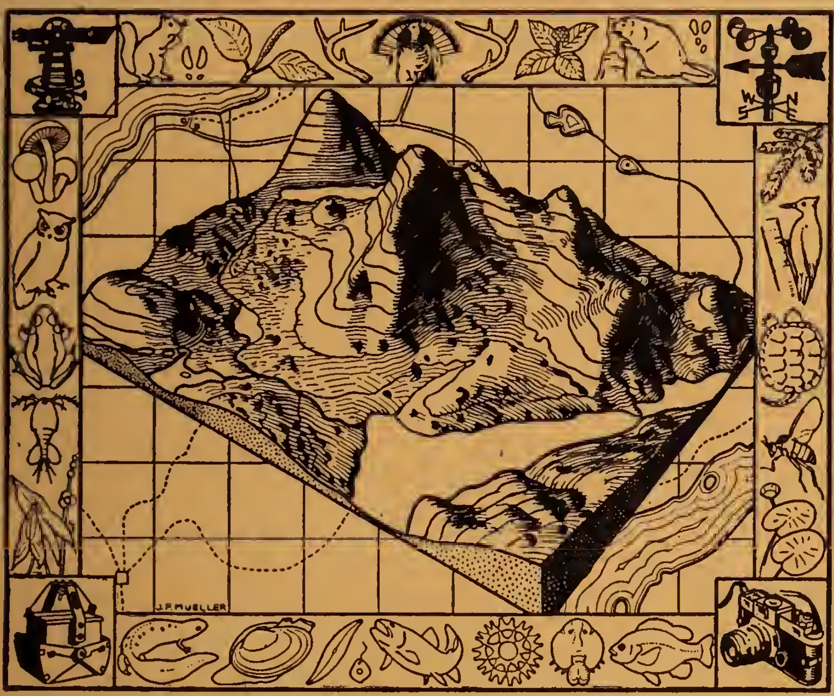
LITTORAL VEGETATION OF THE LAKES ON THE HUNTINGTON FOREST

By

HAROLD F. HEADY



ROOSEVELT WILDLIFE BULLETIN

VOLUME 8 JUNE, 1942 NUMBER 1

Roosevelt Wildlife Forest Experiment Station

New York State College of Forestry
at Syracuse University, Syracuse, N. Y.

Samuel N. Spring, Dean

The Cover Design

The 15,000-acre Huntington Wildlife Forest Station in the Central Adirondacks is the field headquarters of the Roosevelt Wildlife Forest Experiment Station. The Roosevelt Station's field program is almost wholly devoted to the development of this area and the study of conditions prevailing there. The cover design of the *Bulletin* is based on this program of work and is illustrative of its nature and purpose. Emphasis is placed on the check-area, a 5,000-acre tract in the north central part of the Forest reserved for intensive field study and laid out in 40-acre compartments to facilitate these studies. The central portion of the design is a drawing of the relief map of the check-area superimposed on a portion of the grid map of the same area. The several pieces of equipment included in the border indicate the varied nature of the research work, and the numerous plants and animals depicted illustrate the variety of species and conditions occurring on the Forest.

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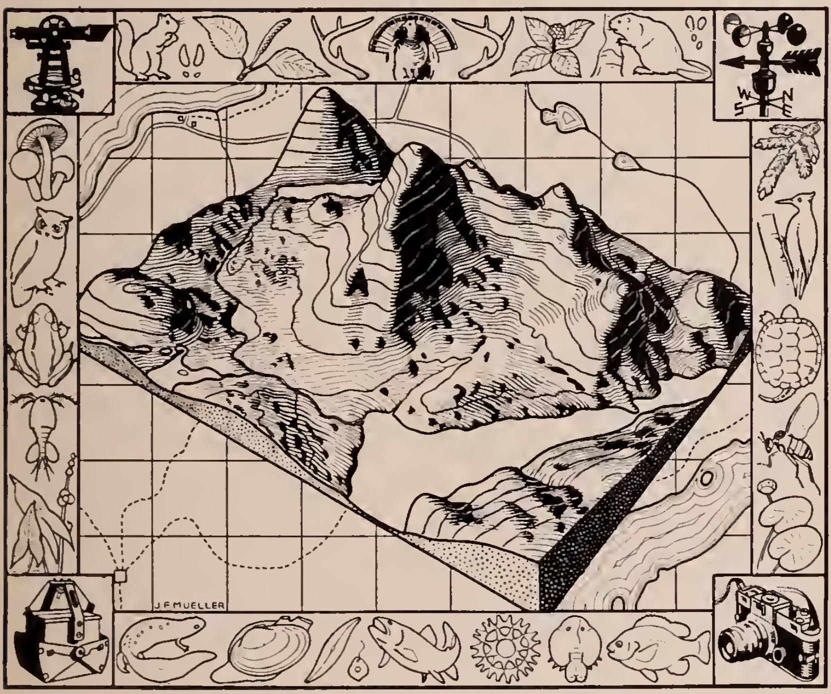

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The serial publications of the Roosevelt Wildlife Forest Experiment Station consist of the following:

1. **Roosevelt Wildlife Bulletin**
2. **Service Publication**

The *Bulletin* includes papers of a technical or semi-technical nature dealing with the various phases of forest wildlife, its management and conservation. The *Service Publication* is intended to be of general and popular interest and attempts to interpret forest wildlife research results and explain the reasons for and methods of their application.

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FIG. 1. Dead arbor vitae along the shore of Wolf Lake killed during period of high water.

FIG. 2. Sandy beach along the south shore of Rich Lake near the east end.

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By

HAROLD F. HEADY

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INTRODUCTION

The problem. This report embodies observations made by the author during July and August, 1940, while he was employed at the Archer and Anna Huntington Wildlife Forest Station[1] near Newcomb, New York. A preliminary survey was made of the aquatic vegetation in five lakes on the Forest, exclusive of the phytoplankton and the attached algae (except *Chara* spp. and *Nitella* spp.). The data obtained are presented with emphasis upon the coverage (percent of the bottom covered), because the cover seems to be very closely correlated with the number of animals that will find food and protection in the littoral area. It has been stated (Welch, '35) that the vegetation of the littoral area in any lake is an important factor of the productivity of the lake. The measurements, then, of the amount of vegetation in the littoral area should be one of the first steps in determining the productivity of a lake.

[1] Hereafter referred to as the "Huntington Forest" or "Forest."

Location and extent of the area. The Huntington Forest, a rectangular tract of land, 15,000 acres in extent, is located in the central part of the Adirondacks west of the village of Newcomb, New York. The tract is held in trust by Syracuse University for the New York State College of Forestry "for investigation, experiment and research in relation to the habits, life histories, methods of propagation and management of fish, birds, game, food and fur-bearing animals and as a forest of wildlife" (Johnson and Dence, '37).

Climate. No weather data are available for the Huntington Forest prior to July 1940, but the general climate may be inferred from weather data collected not more than 25 miles distant. A weather station has been maintained in continuous operation at the Arbutus Lake headquarters since July 1, 1940 in cooperation with the United States Weather Bureau, through its New York section at Albany.

During the growing season of most years the precipitation, which varies from 4 cm. to 8 cm. per month, is sufficient for plant growth. The temperature is quite variable, ranging from a mean monthly low of about −11°C. or −12°C. in January and February to a mean monthly high of slightly more than 15°C. in July (Mordoff, '34). The greatest daily high in the summer of 1940 was 30.1°C.

Acknowledgments. The writer is especially grateful to Mr. W. A. Dence, who assisted him at various times during the summer and who has furnished some of the data for Rich Lake. Credit also is due Dr. H. F. A. Meier, Dr. R. R. Hirt and Dr. J. L. Lowe of the Department of Forest Botany and Pathology for their constructive criticisms of the manuscript.

GENERAL FEATURES OF THE LAKES

Geology of the lake basins. The valleys in the Huntington Forest are probably fault troughs, or some may be subsequent along lines of weakness. At least two systems of faults are present as shown by the trellised drainage pattern (Fenneman, '38). However, as the two systems are known only from the forms of the valleys, a more complete knowledge of the geologic structure in the Forest and in the entire Adirondacks region would probably change these statements somewhat. The lakes of the Huntington Forest usually lie above dams of glacial drift. In the case of Wolf Lake the dam is at the south end of the lake causing a westward drainage from the north end of the lake to Deer Brook—the outlet of Deer Lake. Deer Lake is at the junction of two valleys, but in this case the outlet is over the dam. Catlin, Rich and Arbutus

Lakes are similarly situated above morainal dams. Wolf Lake is the highest and drains into Catlin Lake as does Deer Lake. Catlin and Arbutus drain into Rich Lake, which in turn empties into the Hudson River near the village of Newcomb.

Size. The five lakes studied are not large, ranging in area from 94.4 acres to 536.1 acres, and in depth from 10 feet to 60 feet (Table 1).

TABLE 1. AREA AND DEPTH OF THE LAKES (KING, ET AL., '41).

NAME OF LAKE	Surface Area (Acres)	Maximum Depth (Feet)
Catlin	536.1	55
Rich	395.9	60
Wolf	143.7	45
Arbutus	120.8	26
Deer	94.4	10

The areas were determined with a planimeter from maps drawn from a winter survey.

Shape. All of the lakes are distinctly linear (Plates 1-5) and the long axis of each parallels the long axis of its respective valley. The widths of the lakes are largely determined by the widths of the valleys in which they are located, since they almost cover the valley floors. Rich Lake is the only one with a very irregular shore line, which is the result of a long peninsula (an island during periods of high water) projecting into the lake from the eastern end. There are four islands in Arbutus, two in Wolf, one each in Deer and Rich, and none in Catlin. They are not important features in the productivity of these lakes because the littoral zone of the bottoms surrounding them is usually sandy and stony, and because they are quite small.

Relation to air currents. The effects of wind on the shore line, on thermal stratification, and on horizontal distribution of plankton for lakes in general are well known. The prevailing wind on Catlin, Deer, and Arbutus lakes was usually from the northwest, blowing approximately parallel with their long axes. The prevailing wind over Wolf Lake was from north to south, and for Rich Lake from west to east, again parallel with their long axes.

The different directions of the prevailing winds in the valleys were probably due to variations in local topography. Where there was extensive wave action on the shore, vegetation was very sparse and the bottom was usually sandy or stony.

Types of Bottom. Several types of bottoms were present in these five lakes. Smooth rock ledges were scarce, occurring only at widely separated places in Catlin, Wolf and Deer lakes and especially along the peninsula in Rich Lake. Boulders, gravel, and sand covered by far the greatest percentage of the bottom in the littoral zone in all the lakes. In the deeper parts of the lakes muck or ooze had collected to such an extent that it covered the mineral bottom completely. Semi-bog conditions have resulted in an accumulation of peat and the formation of a sphagnum mat along the southwest side of Deer Lake. The ooze was very soft at the edge of the mat. As far as could be determined clay was very rare, occurring along the shore in a few areas in Catlin Lake. Shore conditions in Wolf Lake are worthy of special mention. A number of years previous to the time of the present study, beaver dammed the outlet which raised the lake level three or four feet, killing a fringe of trees around the lake. Later, beaver abandoned the area and shortly thereafter the dam was washed away, allowing the lake to return to its original level. At the present time many of the dead trees have fallen into the water, affording protection and a place of attachment for animal and plant forms of the lower phyla. Occasionally in slight pockets in the sandy and gravelly areas of the lakes there were accumulations of small twigs and larger débris from the bordering forests.

FLORISTICS

The scientific names in this report are those used in an earlier paper (Heady, '40) ; therefore authorities are not included as they are given in that publication.

During the course of the field work Fassett's *Manual of Aquatic Plants* ('40) was found very helpful. However, Fassett's naming of sterile submersed forms of a few species was found impractical to follow in field work on the Huntington Forest. In the few following cases the characters of the submersed forms intergraded in nature with the emergent forms, often only a few feet away. When writing of *Hypericum boreale* forma *callitrichoides* Fassett, he states: "Usually the terrestrial form may be found on the shore nearby, or a partially submersed plant may have the emersed part characteristic of the land plant." This form and also *Pontederia cordata* L. forma *taenia* Fassett.

Juncus pelocarpus Mey forma *submersus* Fassett, and *Eleocharis acicularis* R. & S. forma *inundata* Svenson are considered ecological variants on the Forest not worthy of nomenclatural recognition.

Forty-seven segregates were recognized in the different lakes. Forty-four of these were seed plants, two of which could not be identified. Of the other three, two were algae and the other a moss. Every observed species is included in the tables (3-10) even though only one individual was seen in the lakes.

METHODS

Quantitative methods for the survey of higher aquatic plants have not been perfected to the extent that entirely satisfactory results can be obtained. However, two men working together can obtain good results with a rectangular iron frame, one-half square meter in size. All of the plants are collected within the frame and their air-dry weights determined by species (Rickett, '22). By this method a few plants are likely to be lost in the water, and the frame usually includes the tops of plants leaning over the selected area, especially if there are water currents. The water in northern latitudes is too cold for extensive diving. Neither are comparable parts always taken of all the species, because the roots of some may be left in the soil. Wilson ('37) describes a quantitative method of sampling aquatic vegetation with the aid of the Peterson dredge which denudes an area 625 square centimeters in extent. It is practically impossible to get consistent samples of floating leaves with this dredge, especially if the water is deep.

The method used in this survey is based upon ocular estimates of the space relationships, of the abundance, and of the area covered by each species. The results may not be compared statistically because of the personal error introduced with the ocular method of measurement.

The equipment used included a rowboat with an outboard motor, a glass-bottom bucket, and a long handled garden rake.

From an initial very superficial survey of the shore and a study of a topographic map of the lake basin, areas of the bottom of nearly uniform conditions of vegetation and topography were delimited from the water's edge to about the ten-foot depth. These stations or shore areas varied greatly in size depending entirely upon the extent of practically uniform conditions. The number of stations in the lakes were: Catlin, 31; Rich, 33; Wolf, 13; Arbutus, 8; and Deer, 8 (Plates 1-5).

The vegetation within each station was studied with the aid of the glass-bottom bucket which was used to break the water surface making

possible better under-water vision. Any plant individuals of uncertain identity were procured with the rake for closer examination and identification. Every species seen in the station was listed in the field notes by symbol, which was usually the first letter of the genus name plus the first two letters of the species name; and after each, ocular estimates of the percent of bottom covered, space relationships, and abundance were noted.

Coverage is here used as the amount of bottom covered by all the individuals of the species, and is written as a percent of the bottom area in the zone where the species grew. The average range of depths within which a plant grew was determined by a large number of soundings. For example, the depths for *Nuphar advena* var. *variegata* averaged from 3.5 to 5.5 feet. Even though many individuals grew in deeper or shallower water than these figures would indicate, by far the greater number were within the depths specified. The figures for average depths in all cases were rounded to the nearest half-foot because fluctuations in the lake levels made further accuracy impractical.

By grouping the species according to their average depths it was possible to recognize three depth zones in the lakes. The shallowest or emergent zone between the 0 and 2.5-foot depths, the floating-leaved zone between the 2- and 5-foot depths, and the deepest or submerged zone between the 4- and 9-foot depths. In nature these zones do not have sharp boundaries; there exist transition or ecotone areas between them. The writer observed many areas where the community of the floating-leaved zone slightly overlapped the other two zones, similar to a shrub community overlapping small herbs and grasses at its outer border. It seems, then, that calculating areas as doubly covered along the sides of the middle or floating-leaved zone more nearly represents actual conditions than if one zone began where another stopped. The areas of the three zones in the lakes are given in Table 2.

Table 2. Areas (in Acres) of the Three Zones in the Lakes.

ZONES	Catlin L.	Rich L.	Wolf L.	Deer L.	Arbutus L.
Between 0- and 2.5-foot depths.	37.7	25.9	10.4	14.8	18.2
Between 2- and 5-foot depths...	45.2	31.0	12.5	25.3	22.8
Between 4- and 9-foot depths...	186.1	45.8	13.3	28.6	30.1
Total......	269.0	102.7	36.2	68.7	71.1

These areas were calculated from the contour maps by using a planimeter. Fractions of the areas between contour lines were determined by interpolation.

When the coverage was thought to be less than 5 percent of the zone a "– 1" was recorded, and a "T"[1] was recorded if the coverage was thought to be less than 0.5 percent. If the coverage was over 5 percent it was estimated to the nearest 10 percent; thus "1" indicates 5 to 15 percent, "2" indicates 16 to 25 percent, etc.

The station figures by species were totaled, in calculating the coverage, and the sum multiplied by 10. This gave the total percent of that species in the lake. To find the average percent of the zone covered the total percent of each species was then divided by the number of stations in the lake multiplied by 100, the highest percent possible coverage. In other words the total of the actual percents of coverage for one species in all the stations was divided by the highest possible percent to find the percent of the zone totally covered. This figure multiplied by the acres in the zone gave an approximation of the area totally covered by a species in the lake. When a plant was recorded as – 1, four of them were taken as equal to 1 or 10 percent. The sum of the coverage of all the species equalled the acres of the zone totally covered.

The space relationships are here used to mean the nearness of individuals of any species ("sociability" of Braun-Blanquet), and is not to be confused with the number of individuals present. In estimating the space relationships the units used and their meanings are as follows: "1", one plant in a place; "2", plants grouped or tufted; "3", plants in small patches or cushions; "4", plants in small colonies or extensive patches; and "5", pure populations. The figures of the space relationships for each lake were averaged. Thus an average of 2.5 means that the individuals were in rather large groups.

The number of individuals or abundance was estimated to be one of five classes: "1", very sparse; "2", sparse; "3", infrequent; "4", numerous; and "5", very numerous. It would have been very time consuming to count the individuals of each species in a large station, but it would make possible the substitution of numbers for the relative terms. However, in the estimations, when less than ten individuals were present, the species was considered to be very sparse. Sparse in this instance means about 10 to 25 individuals. Classes 3, 4, and 5 were still more difficult to assign actual figures, but few plants were ever sufficiently represented to be "very numerous". The abundance figures of each species within each lake were also averaged. The averages of abundance for

[1] "T" is used as the abbreviation of trace.

the species in a zone are numerical expressions of the relative number of individuals present.

Frequency, the distribution in space, was taken from the abundance table, as the number of plots in which the species occurred was necessary for computing the average figure for abundance.

This system of ocular estimate of the physiognomy and structure of the vegetation leaves a great deal to be desired and is at best relative and only as accurate as the collector's judgment. Undoubtedly another worker would not obtain the same figures from a similar survey of the same area. However, it is believed that a combination of the estimates plus a knowledge of the general appearance of the species gives a reasonably good picture of the cover and arrangement of the plants present. Thus, in station 1 in Catlin Lake, individuals of *Nuphar advena* var. *variegata* were separate (unit 1 of space relationships), infrequent (unit 3 of abundance), and covered 15 to 25 percent of the zone between the 3.5- and 5.5-foot depths. The high coverage in spite of the low space and abundance figures was due to the large floating leaves. In the case of *Eriocaulon septangulare,* in the same station, the plants were in small patches, numerous, and with the same coverage of 15 to 25 percent. The individuals of this species were small; therefore many more were required to cover the same percent of the zone as did *Nuphar advena* var. *variegata.*

VEGETATION

Submerged zone. By using the average depths for all the species, there seemed to be, as previously stated, three rather distinct zones of vegetation around the lakes. Beginning in the deeper water there was a zone of completely submerged plants occurring between the average depths of 4 and 9 feet. The soil that supported plants in this zone was largely muck or ooze with some mineral content that had washed from the shallower depths. It should be noted that not all of the completely submerged plants were in this zone, but many occurred in the floating-leaved zone.

In Catlin and Rich lakes the dominant plants of the submerged zone were *Chara* spp. and *Vallisneria americana,* as they were the most frequent and covered the greatest area (Tables 3-4). *Vallisneria americana* usually did not occur in patches, but was quite widespread in its distribution. These two plants were favored if the bottom was a mixture of muck and sand. Probably this type of bottom was a result of greater wave action in the longer lakes as the wind had a longer sweep. No measurements were made of the winds on the various lakes, but it was

TABLE 3. COVERAGE IN THE SUBMERGED ZONE.

SPECIES	Av. Depth (Feet)	Catlin Lake		Rich Lake		Wolf Lake		Deer Lake		Arbutus Lake	
		Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres
Chara spp.	3—10	2.4	4.47	8.5	3.89	0.0	0.00	1.9	0.54	3.1	0.93
Potamogeton robbinsii	6—10	1.0	1.86	0.2	0.09	0.0	0.00	0.0	0.00	T	T
Utricularia purpurea	2—10	0.0	0.00	0.2	0.09	0.4	0.05	15.0	4.29	33.1	9.96
Utricularia vulgaris var. americana	4—8	1.5	2.79	0.8	0.37	0.0	0.00	5.6	1.60	T	T
Vallisneria americana	3.5—7	3.9	7.25	1.5	0.69	0.0	0.00	1.9	0.54	1.2	0.36
Total		8.8	16.37	11.2	5.13	0.4	0.05	24.4	6.97	37.4	11.25

TABLE 4. FREQUENCY IN THE SUBMERGED ZONE.

SPECIES	Catlin L. 31 stations	Rich L. 33 stations	Wolf L. 13 stations	Deer L. 8 stations	Arbutus L. 8 stations
Chara spp.	14	24	0	5	5
Potamogeton robbinsii	4	2	0	0	3
Utricularia purpurea	0	4	4	8	8
Utricularia vulgaris var. americana	4	5	0	6	4
Vallisneria americana	20	12	0	8	6

noticed that the waves were frequently higher in Catlin and Rich lakes as compared with the others.

In Deer and Arbutus lakes where the bottom in the submerged zone was nearly pure muck, *Utricularia purpurea* was both the most frequent and covered the greatest area. This species is usually considered to be free-floating, but in the two lakes where it was most abundant the individuals were partly buried in the muck with the growing ends extending upward. Occasionally deer or wind would break some of the stems and these would gather as large free-floating masses. The second most frequent species in these two lakes was *Vallisneria americana*, but it did not cover as much area as *Utricularia vulgaris* var. *americana* in Deer Lake, nor as much as *Chara* spp. in Arbutus Lake. However, these three species were scattered and distinctly subdominant to *Utricularia purpurea* in the community. Since Deer Lake is only 10 feet deep seed plants would be expected to grow nearly everywhere on the bottom, but the rather turbid water resulted in a light deficiency for most species at about seven feet. Only a few specimens of *Utricularia* were found in deeper water.

The submerged community was practically non-existent in Wolf Lake, being represented by only a few individuals of *Utricularia purpurea*. The slope of the bottom was very steep and very little muck was present at depths of less than 10 feet.

The only area in any of the lakes where the zone supported anything approaching a total plant coverage occurred along the south shore of Rich Lake, stations R-5 and R-6, on a broad flat bench between the 5- and 15-foot depths. *Chara* spp. in large patches and *Fontinalis novae-angliae* were dominant in a few areas. Few plants occurred in water over 10 feet in depth. However, there were a few individuals of

Potamogeton robbinsii near the 10-foot depth. Sewage from a nearby CCC camp emptied into the lake through a pipe which ended beyond the plant zone in this area. The effects of the sewage upon the higher plants probably was slight as the abundant species seemed to depend upon the type of bottom and the depth of water rather than on proximity to the terminus of the sewer pipe.

The acres of total plant coverage of the submerged zone in the different lakes varied from 0.05 in Wolf Lake, 5.13 in Rich, 6.97 in Deer, 11.25 in Arbutus to 16.37 in Catlin. This zone was most important in Arbutus Lake and Deer Lake where 37.4 and 24.4 percent, respectively, of the zones were covered. In Rich, Catlin and Wolf lakes the total plant cover was only 11.2, 8.8, and 0.4 percent of the zones. However, this zone had the least plant cover with the exception of the emergent zone in Arbutus Lake and Deer Lake.

Floating-leaved zone. The floating-leaved zone was by far the most important of the three zones in productivity, not because of the width of the zone, but because of the admixture of mineral and organic material on the bottom which was very favorable for plant growth. The communities in this zone were somewhat different in the various lakes and are treated for each lake rather than as a group. The zone in each lake was considered a unit because the variations of bottoms in the different lakes seemed to make more diversity in vegetation than various bottoms within any one of the lakes. For example, in Catlin Lake, relative proportions of individuals of the important species were found to be about the same in the bays, where the bottom was a mixture of sand and muck, at the north end of the lake, where the bottom was nearly pure muck, and in the areas where the bottom was mostly sand and rock. A few of the subdominant species were present only at the north end of the lake, but as the bottom gradually changed to a higher content of gravel and rocks, the proportion of the number of individuals of the different species remained the same.

Not all the species in the floating-leaved zone have floating leaves. The criterion as to whether a plant was in the zone or not was the average depths between which it grew. The depths for some plants like *Najas flexilis, Scirpus subterminalis,* and *Potamogeton pusillus* var. *typicus* were between one and seven feet for the first and one and six feet for the last two. Others were growing on the shallow side of the zone, and a few on the deep side, but in general the average of all the depths was between two and five feet.

The community in Catlin Lake was typified by four species, *Nuphar advena* var. *variegata, Potamogeton epihydrus, Potamogeton pusillus*

TABLE 5. COVERAGE IN THE FLOATING-LEAVED ZONE.

SPECIES	Av. Depth (Feet)	Catlin Lake		Rich Lake		Wolf Lake		Deer Lake		Arbutus Lake	
		Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres
Brasenia schreberi	1—5	0.8	0.36	2.1	0.65	1.5	0.19	8.7	2.21	8.1	1.85
Elodea occidentalis	3—5	5.0	2.26	0.0	0.00	T	T	T	T	0.0	0.00
Myriophyllum farwellii	1.5—7	0.8	0.36	0.0	0.00	0.0	0.00	0.0	0.00	1.2	0.27
Najas flexilis	1—7	0.3	0.14	8.2	2.54	0.8	0.10	1.9	0.48	3.8	0.86
Nitella spp.	1—4	1.5	0.68	5.2	1.61	T	T	7.5	1.90	5.6	1.28
Nuphar advena var. variegata	3.5—5.5	14.5	6.55	9.1	2.82	2.3	0.29	5.0	1.27	6.9	1.57
Nuphar microphyllum	4	0.0	0.00	0.3	0.09	0.0	0.00	0.0	0.00	0.6	0.14
Nymphaea odorata	2—5	1.5	0.68	1.1	0.34	0.4	0.05	4.4	1.11	6.3	1.44
Nymphoides lacunosum	1—5	1.0	0.45	0.2	0.06	0.0	0.00	0.0	0.00	0.0	0.00
Potamogeton amplifolius	2.5—4	0.0	0.00	0.8	0.25	0.0	0.00	1.9	0.48	0.6	0.14
Potamogeton capillaceus	1.5—3.5	0.0	0.00	1.2	0.37	0.8	0.10	2.5	0.63	0.0	0.00
Potamogeton epihydrus	2.5—5	7.9	3.57	2.7	0.84	0.4	0.05	2.5	0.63	T	T
Potamogeton gramineus var. graminifolius	2—4	0.0	0.00	0.2	0.06	0.0	0.00	0.6	0.15	0.0	0.00
Potamogeton natans	3—5	1.6	0.72	T	T	0.0	0.00	0.0	0.00	1.2	0.27
Potamogeton perfoliatus	3—5	1.0	0.45	3.2	0.99	0.0	0.00	0.0	0.00	0.0	0.00

TABLE 5. COVERAGE IN THE FLOATING-LEAVED ZONE—*Continued*

SPECIES	Av. Depth (Feet)	Catlin Lake		Rich Lake		Wolf Lake		Deer Lake		Arbutus Lake	
		Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres
Potamogeton pusillus var. typicus......	1—6	6.3	2.85	1.8	0.56	T	T	T	T	T	T
Scirpus subterminalis..................	1—6	1.3	0.59	1.7	0.53	T	T	21.9	5.54	17.5	3.99
Sparganium angustifolium.............	1—3	1.3	0.59	0.5	0.16	T	T	1.9	0.48	0.0	0.00
Sparganium fluctuans.................	0.5—4	2.4	1.08	1.8	0.56	T	T	0.0	0.00	2.5	0.57
Utricularia gibba.....................	1—4	0.5	0.23	T	T	0.0	0.00	T	T	T	T
Total.......................		47.7	21.56	40.1	12.43	6.2	0.78	58.8	14.88	54.3	12.38

TABLE 6. FREQUENCY IN THE FLOATING-LEAVED ZONE.

SPECIES	Catlin L. 31 stations	Rich L. 33 stations	Wolf L. 13 stations	Deer L. 8 stations	Arbutus L. 8 stations
Brasenia schreberi	5	18	5	5	5
Elodea occidentalis	22	0	1	2	0
Myriophyllum farwellii	3	0	0	0	4
Najas flexilis	12	29	4	8	8
Nitella spp	8	25	4	8	8
Nuphar advena var. variegata	31	30	9	7	8
Nuphar microphyllum	0	2	0	0	1
Nymphaea odorata	9	6	1	6	6
Nymphoides lacunosum	3	2	0	0	0
Potamogeton amplifolius	0	9	0	4	2
Potamogeton capillaceus	0	7	4	4	0
Potamogeton epihydrus	26	26	3	7	4
Potamogeton gramineus var. graminifolius	0	2	0	3	0
Potamogeton natans	3	2	0	0	5
Potamogeton perfoliatus	4	24	0	0	0
Potamogeton pusillus var. typicus	25	24	5	3	2
Scirpus subterminalis	6	10	3	8	6
Sparganium angustifolium	8	7	2	6	0
Sparganium fluctuans	14	18	2	0	6
Utricularia gibba	5	2	0	6	2

var. *typicus,* and *Elodea occidentalis* (Tables 5-6). These are named in order of coverage and frequency beginning with the species that covered the greatest area and with the species that was most frequent. Of these *Nuphar advena* var. *variegata* was most important, forming a nearly complete belt around the lake. At the north end of Catlin Lake the community was broad and there *Nuphar advena* var. *variegata* occurred in small bunches. This plant seemed to prefer the mixture of sand and muck that was the most widespread bottom type in this zone in Catlin Lake.

Fig. 3. White waterlily (*Nymphaea odorata*) in Arbutus Lake. The coverage by this species in the zone represented is about 20 percent.

Fig. 4. Water shield (*Brasenia schreberi*) in Arbutus Lake. The coverage is about 50 percent. Note the insect damage to the leaves.

The total coverage in the zone in Catlin Lake was 21.2 acres or about 47 percent of the area.

In Rich Lake *Nuphar advena* var. *variegata, Najas flexilis, Potamogeton epihydrus, Nitella* spp., *Potamogeton perfoliatus,* and *Potamogeton pusillus* var. *typicus* were the most frequent in the floating-leaved zone. This community was somewhat different from the one in Catlin Lake, but the causes for the difference were not fully known, although greater wind action, a longer growing season, and the presence of some calcareous outcrops along the shores may have been important factors. The number of species in the zone in Rich Lake was 18 as compared to 16 in Catlin Lake, but the two lists were not entirely the same. *Elodea occidentalis* and *Myriophyllum farwellii*, present in Catlin Lake, were not found in Rich Lake. On the other hand, *Nuphar microphyllum, Potamogeton amplifolius, Potamogeton capillaceus,* and *Potamogeton gramineus* var. *graminifolius* were present only in Rich Lake. The presence of *Elodea occidentalis* in Catlin Lake and its absence from Rich Lake was the most noteworthy difference. *Elodea* was not found in Arbutus Lake and occurred only in one station in Wolf Lake and two in Deer Lake.

None of the dominants was markedly more frequent unless it was *Nuphar advena* var. *variegata* which in many areas was quite conspicuous in an area 10 to 30 feet wide between the 3.5- and 5.5-foot depths. As to coverage *Nuphar advena* var. *variegata* was most important with *Najas flexilis* a close second and *Nitella* spp. third. The other three species covered less area and only were included as characteristic species on the basis of their high frequency.

The zone in Rich Lake, 31.0 acres in extent, was only 40.2 percent covered; resulting in 12.46 acres of totally covered bottom. There were 21.2 acres of totally covered bottom in the zone in Catlin Lake as it had a larger area, 45.2 acres, and a coverage of 46.9 percent.

The zone was very poorly developed in Wolf Lake except in the two bays at the south end of the lake and the entire north end. These communities were dominated by *Nuphar advena* var. *variegata* and *Brasenia schreberi*. *Potamogeton pusillus* var. *typicus, Najas flexilis*, and *Nitella* spp. were also present, but were not abundant. The bottom was very oozy in the bays mentioned above, as there was little disturbing wind action. In other places the gradient of the bottom near shore was steep and the bottom rocky. If the floating-leaved zone was present in these areas it was rarely more than a few feet wide. Of the 12.5 acres in the zone only about 0.78 acre was totally covered with plants and

nearly 0.5 acre of that was covered with *Nuphar advena* var. *variegata* and *Brasenia schreberi*.

The conditions in Deer Lake were very different from those in the three lakes just described. The plants occurring most frequently were *Scirpus subterminalis, Potamogeton epihydrus, Najas flexilis,* and *Nitella* spp. The bottom of Deer Lake is nearly pure organic material with very little mineral content, except along the southeast shore which is sandy as a result of wind action, and a few small areas of boulders along the west side. The very mucky conditions favored *Scirpus subterminalis* at the expense of *Nuphar advena* var. *variegata* which was present in scattered bunches in Deer Lake, but was the characteristic species of the zone in the three first mentioned lakes. In the bay included in station 8 (Plate 4) there was a large area nearly covered with *Brasenia schreberi* to the exclusion of other species. This bay had a mucky bottom and was well protected from the wind. These seemed to be the conditions necessary for good growth of this species.

Of the 14.88 acres of total coverage 5.54 were covered by *Scirpus subterminalis,* 2.21 by *Brasenia schreberi,* 1.9 by *Nitella* spp. and 1.27 by *Nuphar advena* var. *variegata.* The remaining four acres were covered by nine additional species.

The floating-leaved zone in Arbutus Lake was very much like the zone in Deer Lake except that *Nuphar advena* var. *variegata* replaced *Scirpus subterminalis* as the most frequent. Others in order of the widest distribution were *Najas flexilis, Nitella* spp., *Scirpus subterminalis,* and *Nymphaea odorata.* The species covering the greatest areas (acres) were *Scirpus subterminalis,* 3.99, *Brasenia schreberi,* 1.85, *Nuphar advena* var. *variegata,* 1.57, and *Nymphaea odorata,* 1.44. Even though Arbutus Lake was much deeper than Deer Lake, conditions in the bay at the outlet and the two bays along the west side of the lake were similar to those in Deer Lake. *Scirpus subterminalis* and *Brasenia schreberi* covered large areas in these three places. The other two species covering considerable areas, especially *Nuphar advena* var. *variegata,* were scattered along the entire shore. Of the scarcer aquatic species in the zone of the five lakes *Myriophyllum farwellii* and *Nuphar microphyllum* were present in Arbutus Lake.

Emergent zone. The emergent zone extended from the shore to the 2.5-foot depth. Not all of the plants found along the shallow water areas were typical of this zone, and those that were typical were scarce because of the severe wave action. During the early part of the season when the water levels were high most of the emergent plants were submerged, but as the season progressed the water levels receded and the

plants grew larger until many of them extended above the water surface. However, many individuals of some of the species never were above water and noteworthy among these were *Eriocaulon septangulare, Myriophyllum tenellum, Sagittaria graminea,* and *Utricularia resupinata.* Some of these produced flower stalks that extended into the atmosphere, but these were often beaten down by the waves. *Isoetes tuckermani* and *Potamogeton spirillus* could be considered in the floating-leaved zone, but the greatest number of them were between the 1.5- and 3-foot depths.

The communities of plants in the emergent zone of the five lakes were very similar (Tables 7-8). *Eriocaulon septangulare* was the most frequent in all the lakes and covered the greatest area except in Rich Lake where it was second to *Isoetes tuckermani. Lobelia dortmanna* was second in frequency in Catlin, Wolf, and Arbutus and *Myriophyllum tenellum* second in Deer. The wide distribution of these species in each lake was probably a result of similar shore conditions. Ice is often two or more feet thick during the winter which undoubtedly has its effect on less hardy plants. During the ice-free season nearly all the shores were beaten by waves, the action of which prevented the accumulation of organic material in less than two feet of water. These wind-swept sandy shores were present in nearly every station. Muck and ooze, present to the water's edge in a few protected bays, supported the plants of the floating-leaved zone nearly to the exclusion of the species characteristic of the emergent zone. However *Isoetes braunii, Pontederia cordata, Potamogeton spirillus,* and *Sagittaria graminea* were the most frequent in areas intermediate between the pure sand and the pure muck where there was a mixture of the two.

Coverage in the zone was not great, ranging from 20.7 percent and 21.1 percent in Arbutus and Rich respectively through 26.7 percent in Deer, 35.6 percent in Wolf, to 37.8 percent in Catlin. Acres totally covered for the lakes in order given above are: 3.77, 5.48, 3.96, 3.70 and 14.25. In Table 5 it will be noticed that several species occurred in this zone in Rich Lake that were not noted in any of the other lakes. Most of these were more abundant on the beach above water and grew in the water only occasionally. They were included for the sake of completeness and because they may or may not have been present in the lakes as a result of fluctuating local conditions of climate and water level.

Variations of water level would result in different areas in all these zones. It must be kept in mind that the maps were made from surveys on the ice when the lakes were nearly at high water and that this vegetation survey was made during late summer when the water levels were low.

TABLE 7. COVERAGE IN THE EMERGENT ZONE.

SPECIES	Av. Depth (Feet)	Catlin Lake		Rich Lake		Wolf Lake		Deer Lake		Arbutus Lake	
		Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres
Callitriche palustris	1.5	0.0	0.00	T	T	0.0	0.00	0.0	0.00	0.0	0.00
Eleocharis acicularis	0—3	0.0	0.00	1.7	0.44	0.0	0.00	0.0	0.00	T	T
Eleocharis palustris	0—1.5	0.0	0.00	0.3	0.08	0.0	0.00	0.0	0.00	0.0	0.00
Equisetum fluviatile	0—1	T	T	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Eriocaulon septangulare	0—3	15.2	5.73	3.9	1.01	17.0	1.77	6.9	1.02	11.3	2.05
Fontinalis novae-angliae	0.5—1	T	T	0.8	0.21	0.4	0.04	T	T	T	T
Hypericum boreale	1	0.0	0.00	T	T	0.0	0.00	0.0	0.00	0.0	0.00
Isoetes braunii	1—2	1.0	0.38	1.2	0.31	0.4	0.04	T	T	T	T
Isoetes tuckermani	1—4	7.7	2.90	6.4	1.66	1.9	0.20	0.6	0.09	1.9	0.35
Juncus pelocarpus	0—2.5	T	T	T	T	0.4	0.04	4.4	0.65	0.0	0.00
Lobelia dortmanna	0—2.5	1.1	0.41	0.6	0.16	8.9	0.93	3.1	0.46	5.6	1.02
Myriophyllum tenellum	0—3	3.2	1.21	1.2	0.31	3.1	0.32	5.6	0.83	T	T
Pontederia cordata	0—2	3.1	1.17	T	T	0.0	0.00	0.6	0.09	1.9	0.35
Potamogeton spirillus	0.5—3.5	4.4	1.66	3.2	0.83	0.4	0.04	1.2	0.18	T	T
Ranunculus reptans	0—1	0.0	0.00	T	T	0.0	0.00	0.0	0.00	0.0	0.00

TABLE 7. COVERAGE IN THE EMERGENT ZONE—*Continued*

SPECIES	Av. Depth (Feet)	Catlin Lake		Rich Lake		Wolf Lake		Deer Lake		Arbutus Lake	
		Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	P cent	Acres
Sagittaria graminea	0—3.5	2.1	0.79	1.2	0.31	T	T	0.6	0.09	T	T
Sparganium americanum	0—1	0.0	0.00	0.6	0.16	0.0	0.00	0.0	0.00	0.0	0.00
Sparganium chlorocarpum var. acaule	0—0.5	0.0	0.00	0.0	0.00	0.4	0.04	0.0	0.00	0.0	0.00
Utricularia intermedia	0—1.5	0.0	0.00	T	T	0.0	0.00	0.0	0.00	T	T
Utricularia resupinata	0—3.5	T	T	T	T	2.7	0.28	3.7	0.55	T	T
Number 1	1—3.5	0.0	0.00	T	T	0.0	0.00	0.0	0.00	0.0	0.00
Number 2	1.5	0.0	0.00	T	T	0.0	0.00	0.0	0.00	0.0	0.00
Total		37.8	14.25	21.1	5.48	35.6	3.70	26.7	3.96	20.7	3.77

TABLE 8. FREQUENCY IN THE EMERGENT ZONE.

SPECIES	Catlin L. 31 stations	Rich L. 33 stations	Wolf L. 13 stations	Deer L. 8 stations	Arbutus L. 8 stations
Callitriche palustris	0	1	0	0	0
Eleocharis acicularis	0	19	0	0	5
Eleocharis palustris	0	1	0	0	0
Equisetum fluviatile	2	0	0	0	0
Eriocaulon septangulare	31	28	13	8	8
Fontinalis novae-angliae	2	16	2	1	3
Hypericum boreale	0	10	0	0	0
Isoetes braunii	5	22	3	4	1
Isoetes tuckermani	24	26	9	3	6
Juncus pelocarpus	8	5	6	7	0
Lobelia dortmanna	27	13	13	7	8
Myriophyllum tenellum	21	15	11	8	6
Pontederia cordata	15	6	0	3	8
Potamogeton spirillus	21	25	2	3	4
Ranunculus reptans	0	1	0	0	0
Sagittaria graminea	16	17	2	5	5
Sparganium americanum	0	2	0	0	0
Sparganium chlorocarpum var. acaule	0	0	1	0	0
Utricularia intermedia	0	2	0	0	3
Utricularia resupinata	1	7	12	8	7
Number 1	0	1	0	0	0
Number 2	0	1	0	0	0

Space relationships and number of individuals. Very important elements in the physiognomy and structure of the vegetation in these lakes were the nearness of individuals of any species (Table 9) and the number of individuals (Table 10) of any species. In general the species that were most frequent and covered the greatest area also were more closely spaced and were present in greater numbers. In the case of *Nuphar advena* var. *variegata* the individuals were some distance apart (1 to 1.7 in the scale), and the number of individuals was not great (1.6 to 2.8), nevertheless the species was a dominant in the floating-leaved zone mostly because of its large floating leaves and high frequency. Other important species with similarly low space and number figures and high coverage and frequency figures were *Brasenia schreberi* and *Potamogeton epihydrus.* When plants like *Chara* spp., *Utricularia vulgaris* var. *americana, Nitella* spp., *Najas flexilis, Scirpus subterminalis, Eriocaulon septangulare, Lobelia dortmanna, Isoetes tuckermani,* and *Potamogeton spirillus* were dominant, they were present in large numbers, and also spaced quite close in small to large pure stands. The plants characteristic of the wave-swept beaches, *Myriophyllum tenellum* and *Utricularia resupinata,* were mostly under the surface of the sand with only flower stalks or leafless stems protruding into the water and atmosphere. These covered very little area even though the individuals were close and were present in large numbers.

The figures for each species indicate in which lake they were most important. For instance individuals of *Scirpus subterminalis* were spaced closer and there were more of them in Deer Lake and Arbutus Lake where the species also covered more area than any other.

TABLE 9. SPACE RELATIONSHIPS.

SPECIES	Catlin L. 31 stations	Rich L. 33 stations	Wolf L. 13 stations	Deer L. 8 stations	Arbutus L. 8 stations
Brasenia schreberi	1.2	1.3	1.4	1.8	1.8
Chara spp.	1.6	2.6	0.0	1.2	2.0
Callitriche palustris	0.0	2.0	0.0	0.0	0.0
Eleocharis acicularis	0.0	2.3	0.0	0.0	1.8
Eleocharis palustris	0.0	3.0	0.0	0.0	0.0
Elodea occidentalis	1.9	0.0	1.0	1.0	0.0
Equisetum fluviatile	1.0	0.0	0.0	0.0	0.0
Eriocaulon septangulare	3.1	2.4	3.6	2.0	3.1
Fontinalis novae-angliae	1.3	1.7	1.5	2.0	1.0
Hypericum boreale	0.0	1.0	0.0	0.0	0.0
Isoetes braunii	1.6	1.5	1.3	1.0	1.0
Isoetes tuckermani	2.2	2.6	1.3	1.7	2.0
Juncus pelocarpus	1.0	1.2	1.3	1.6	0.0
Lobelia dortmanna	1.0	1.3	2.0	1.6	2.0
Myriophyllum tenellum	1.3	1.8	2.0	1.9	1.3
Najas flexilis	1.0	2.3	1.2	1.3	1.1
Nitella spp.	1.6	2.1	1.0	2.5	2.0
Nuphar advena var. variegata	1.7	1.5	1.0	1.0	1.1
Nuphar microphyllum	0.0	1.5	0.0	0.0	2.0
Nymphaea odorata	1.2	1.3	1.0	1.0	1.5
Nymphoides lacunosum	1.3	1.0	0.0	0.0	0.0
Pontederia cordata	1.2	1.0	0.0	1.0	1.3
Potamogeton amplifolius	0.0	1.2	0.0	1.0	1.0
Potamogeton capillaceus	0.0	2.0	1.0	1.5	0.0
Potamogeton epihydrus	1.0	1.0	1.0	1.0	1.0
Potamogeton gramineus var. graminifolius	0.0	1.5	0.0	1.0	0.0

TABLE 9. SPACE RELATIONSHIPS—*Continued*

SPECIES	Catlin L. 31 stations	Rich L. 33 stations	Wolf L. 13 stations	Deer L. 8 stations	Arbutus L. 8 stations
Potamogeton natans	1.0	1.0	0.0	0.0	1.0
Potamogeton perfoliatus	1.0	1.3	0.0	0.0	0.0
Potamogeton pusillus var. typicus	1.3	1.3	1.0	1.0	1.5
Potamogeton robbinsii	1.7	1.5	0.0	0.0	1.0
Potamogeton spirillus	1.1	1.6	1.0	1.0	1.0
Ranunculus reptans	0.0	3.0	0.0	0.0	0.0
Sagittaria graminea	1.2	1.7	1.0	1.0	2.0
Scirpus subterminalis	1.8	2.5	1.3	3.1	3.5
Sparganium americanum	0.0	2.5	0.0	0.0	0.0
Sparganium angustifolium	1.1	1.4	1.0	1.1	0.0
Sparganium chlorocarpum var. acaule	0.0	0.0	2.0	0.0	0.0
Sparganium fluctuans	1.1	1.9	1.0	0.0	1.5
Utricularia intermedia	0.0	1.5	0.0	0.0	1.0
Utricularia gibba	1.0	1.0	0.0	1.0	1.5
Utricularia purpurea	0.0	1.5	1.2	2.5	3.3
Utricularia resupinata	1.0	1.9	1.8	1.6	1.9
Utricularia vulgaris var. americana	1.7	1.8	0.0	1.7	1.0
Vallisneria americana	1.0	1.4	0.0	1.0	1.3
Number 1	0.0	1.0	0.0	0.0	0.0
Number 2	0.0	2.0	0.0	0.0	0.0

TABLE 10. NUMBER OF INDIVIDUALS.

SPECIES	Catlin L. 31 stations	Rich L. 33 stations	Wolf L. 13 stations	Deer L. 8 stations	Arbutus L. 8 stations
Brasenia schreberi	2.0	2.2	1.4	3.0	3.0
Chara spp.	2.4	3.3	0.0	2.2	2.6
Callitriche palustris	0.0	1.0	0.0	0.0	0.0
Eleocharis acicularis	0.0	2.6	0.0	0.0	1.8
Eleocharis palustris	0.0	4.0	0.0	0.0	0.0
Elodea occidentalis	2.2	0.0	1.0	1.0	0.0
Equisetum fluviatile	1.0	0.0	0.0	0.0	0.0
Eriocaulon septangulare	3.8	3.1	4.5	3.1	3.9
Fontinalis novae-angliae	1.5	1.6	1.5	1.0	1.0
Hypericum boreale	0.0	1.0	0.0	0.0	0.0
Isoetes braunii	2.2	2.1	2.0	1.0	1.0
Isoetes tuckermani	3.0	3.5	1.9	2.0	1.8
Juncus pelocarpus	1.2	1.4	1.7	2.6	0.0
Lobelia dortmanna	1.5	1.7	3.4	2.4	3.1
Myriophyllum tenellum	2.7	2.5	2.7	2.8	1.5
Najas flexilis	1.2	3.6	2.0	1.9	2.1
Nitella spp.	2.4	2.9	1.0	3.1	2.5
Nuphar advena var. variegata	2.8	2.7	1.6	2.4	2.1
Nuphar microphyllum	0.0	2.0	0.0	0.0	2.0
Nymphaea odorata	1.9	2.5	2.0	2.3	2.5
Nymphoides lacunosum	2.3	2.5	0.0	0.0	0.0
Pontederia cordata	2.5	1.3	0.0	1.3	1.9
Potamogeton amplifolius	0.0	2.0	0.0	2.2	1.5
Potamogeton capillaceus	0.0	3.3	1.5	1.8	0.0
Potamogeton epihydrus	2.6	2.2	1.7	2.0	1.0
Potamogeton gramineus var. graminifolius	0.0	2.0	0.0	1.7	0.0

Table 10. Number of Individuals—*Continued*

SPECIES	Catlin L. 31 stations	Rich L. 33 stations	Wolf L. 13 stations	Deer L. 8 stations	Arbutus L. 8 stations
Potamogeton natans	2.7	1.5	0.0	0.0	1.4
Potamogeton perfoliatus	2.0	2.5	0.0	0.0	0.0
Potamogeton pusillus var. typicus	2.6	2.4	1.6	1.0	1.0
Potamogeton robbinsii	2.8	1.5	0.0	0.0	0.0
Potamogeton spirillus	2.2	2.6	1.5	1.3	1.0
Ranunculus reptans	0.0	3.0	0.0	0.0	0.0
Sagittaria graminea	2.1	2.6	1.0	1.2	1.4
Scirpus subterminalis	2.5	3.1	1.7	4.4	4.0
Sparganium americanum	0.0	3.0	0.0	0.0	0.0
Sparganium angustifolium	2.0	1.6	1.0	1.7	0.0
Sparganium chlorocarpum var. acaule	0.0	0.0	2.0	0.0	0.0
Sparganium fluctuans	1.9	2.1	1.0	0.0	1.7
Utricularia gibba	1.6	1.5	0.0	1.1	2.0
Utricularia intermedia	0.0	1.5	0.0	0.0	1.7
Utricularia purpurea	0.0	1.3	1.5	3.5	3.9
Utricularia resupinata	2.0	2.0	2.8	2.8	1.7
Utricularia vulgaris var. americana	3.3	2.0	0.0	2.3	2.0
Vallisneria americana	2.1	2.7	0.0	1.8	1.8
Number 1	0.0	1.0	0.0	0.0	0.0
Number 2	0.0	3.0	0.0	0.0	0.0

SUMMARY

This treatment was based largely on coverage or the amount of vegetation present. Since sound methods for the quantitative measurements of aquatic vegetation are as yet lacking, ocular estimates of the coverage, space relationships, and number of individuals seemed the best method for this study. Emphasis was placed on the amount of vegetation because many of the animals present in the lakes depended for their food, either directly or indirectly, upon the producers, the chlorophyll-bearing organisms (attached and free-floating). Many of the animals also sought shelter or a place of attachment in the littoral areas. For example, small fish are comparatively safe from diving birds if they are in an area where lily pads cover the water surface. Many insects also are protected in their immature stages by the leaves of aquatic plants.

In the deeper water or submerged zone the bottom in nearly all the lakes was mostly of organic material and usually *Chara, Utricularia,* and *Vallisneria* were dominant (Fig. 5). If the bottom remained muddy toward shallower water and even above the shore-line the species present were different than where the shore changed to sand. A third group of species occurred if a floating mat was present.

The distributional lines in the diagram from the organic bottom to the sandy shore is possible along probably 75 percent of the shore lines. The mud shore line is also common with best development at the west end of Rich Lake, bays in Arbutus Lake, and at the north end of Catlin Lake. The bog type was well developed only near the outlet of Deer Lake. The rough rocky shore of Wolf Lake supported a very poor development of the sandy shore series.

The terrestrial parts of the distributional lines were determined by casual observation only and they are to be considered as tentative. They are included to show the general space relationships between the littoral vegetation and surrounding forests.

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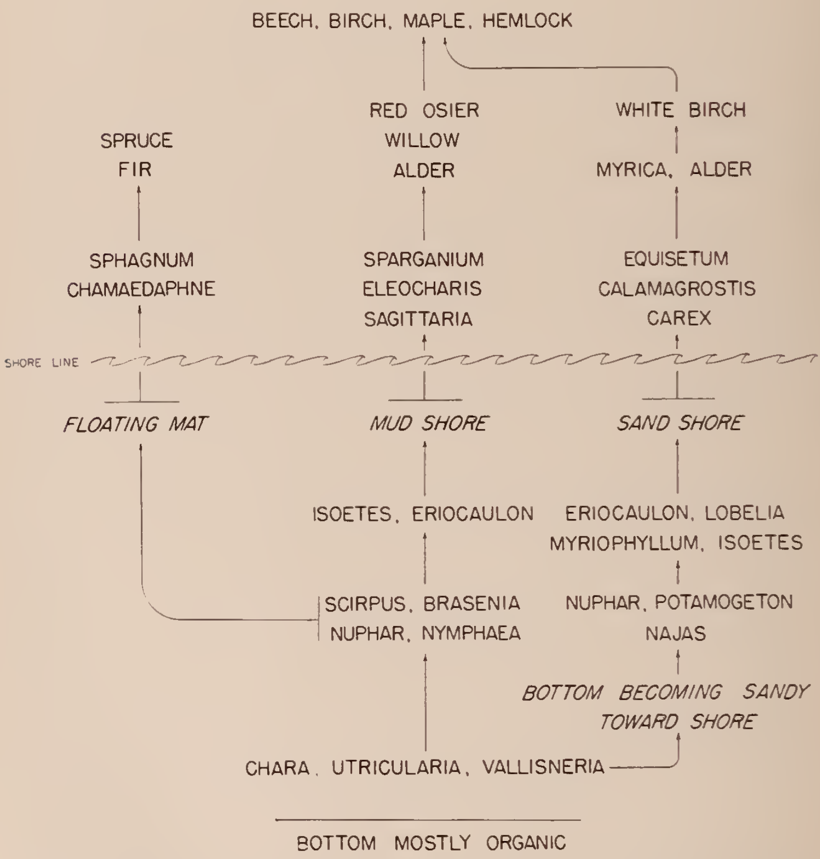

Fig. 5. Diagram of the distribution of the littoral vegetation and the adjacent vegetation on the shores studied. Bottom development is also added. The zones as yet are only tentatively determined above the wavy line.

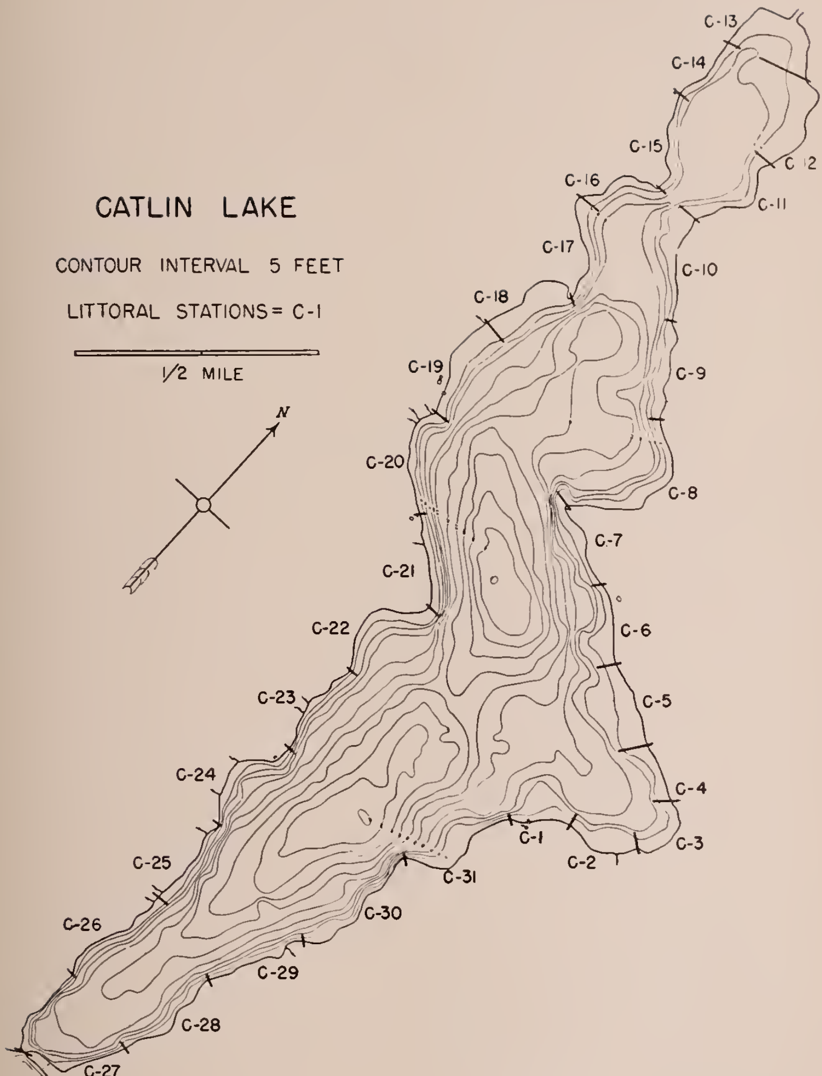
CATLIN LAKE
CONTOUR INTERVAL 5 FEET
LITTORAL STATIONS = C-1
1/2 MILE
N
C-1
C-2
C-3
C-4
C-5
C-6
C-7
C-8
C-9
C-10
C-11
C-12
C-13
C-14
C-15
C-16
C-17
C-18
C-19
C-20
C-21
C-22
C-23
C-24
C-25
C-26
C-27
C-28
C-29
C-30
C-31

Plate I

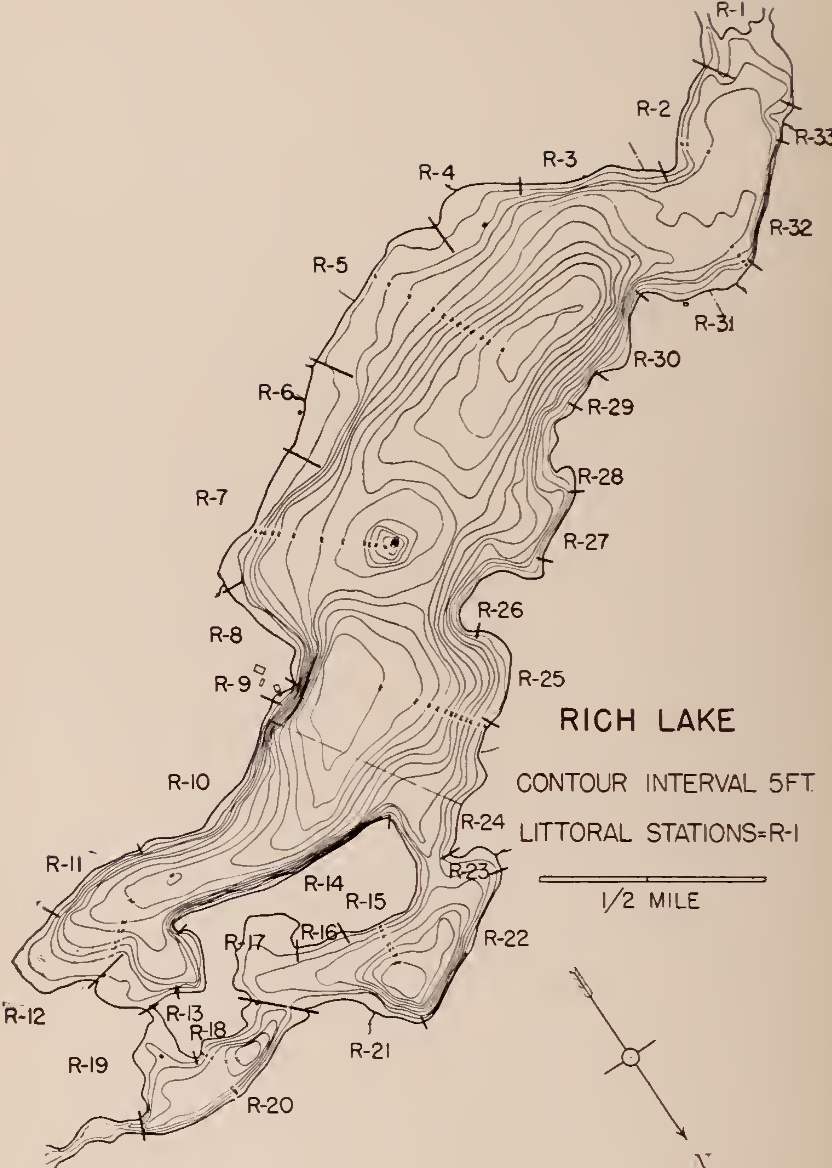
R-1
R-2
R-3
R-4
R-5
R-6
R-7
R-8
R-9
R-10
R-11
R-12
R-13
R-14
R-15
R-16
R-17
R-18
R-19
R-20
R-21
R-22
R-23
R-24
R-25
R-26
R-27
R-28
R-29
R-30
R-31
R-32
R-33
RICH LAKE
CONTOUR INTERVAL 5FT.
LITTORAL STATIONS=R-1
1/2 MILE
N

Plate 2

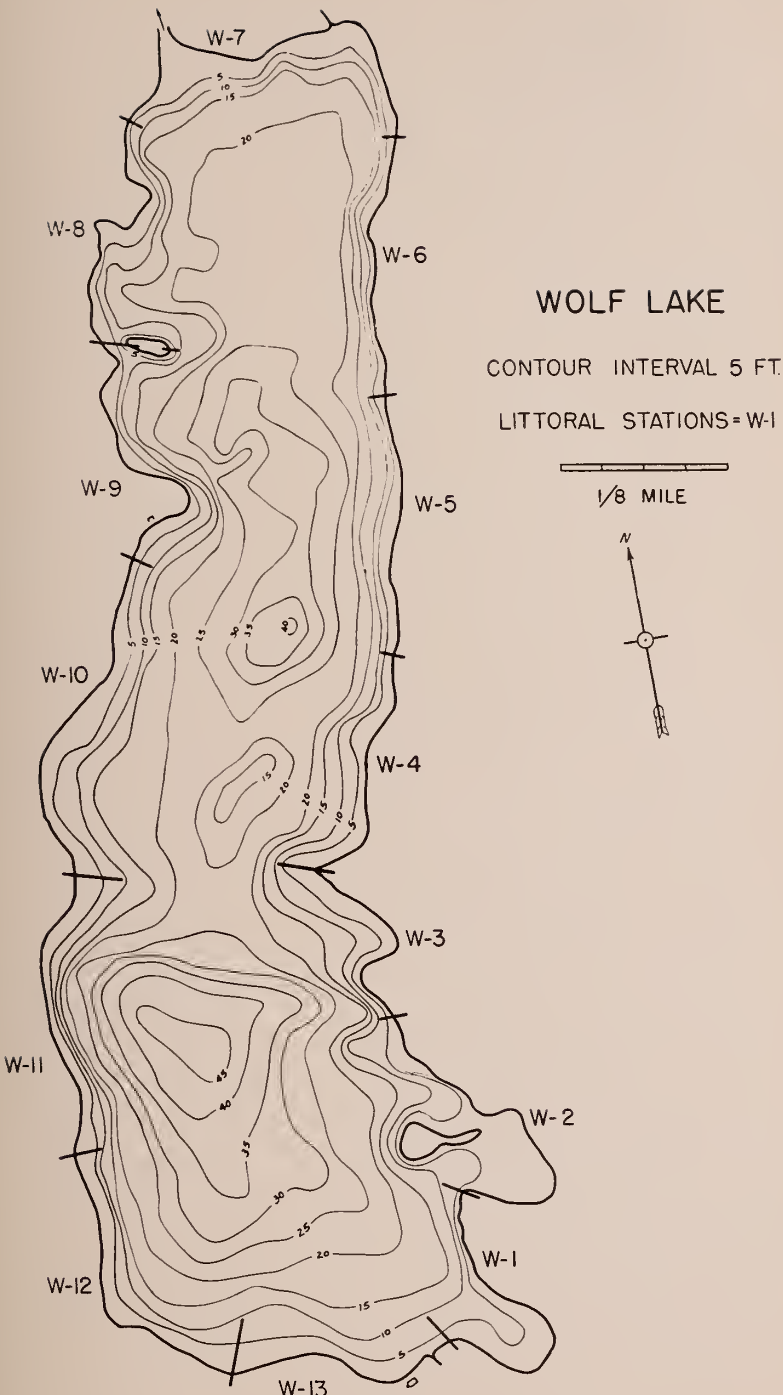
WOLF LAKE
CONTOUR INTERVAL 5 FT.
LITTORAL STATIONS = W-1
1/8 MILE
N
W-1
W-2
W-3
W-4
W-5
W-6
W-7
W-8
W-9
W-10
W-11
W-12
W-13

Plate 3

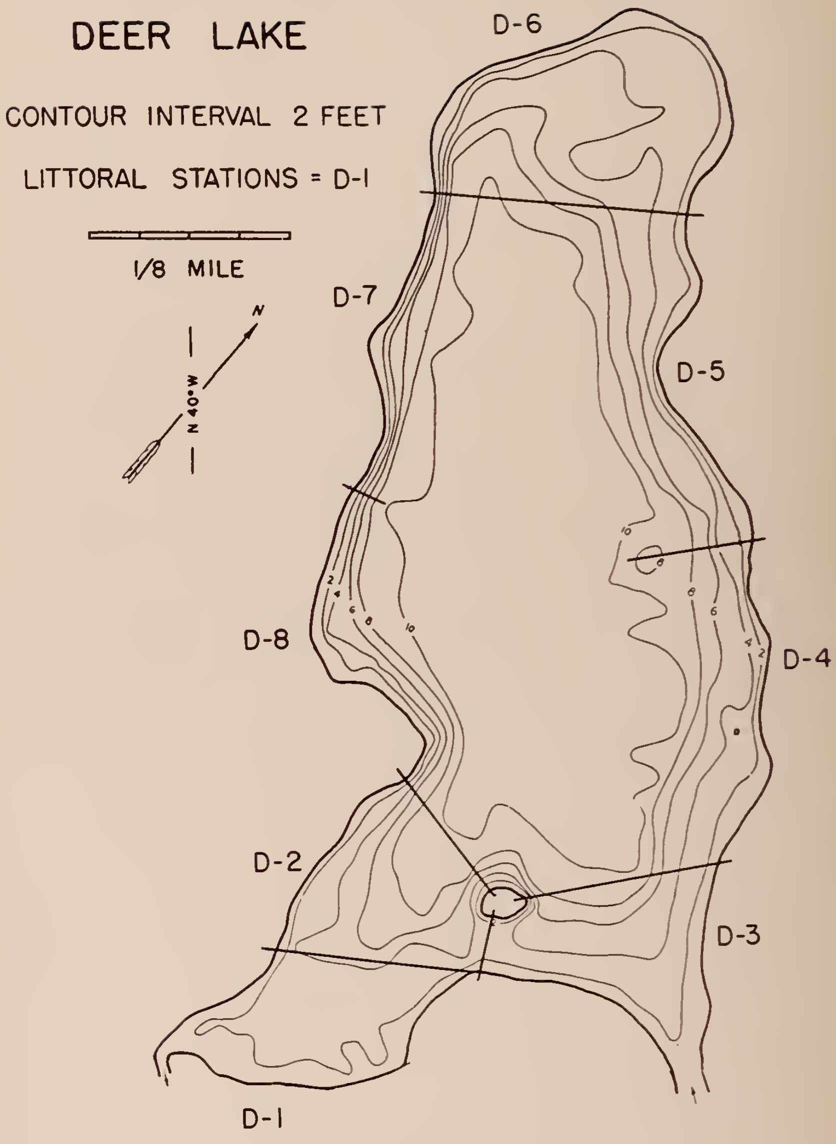
DEER LAKE
CONTOUR INTERVAL 2 FEET
LITTORAL STATIONS = D-1
1/8 MILE
N
N 40° W
D-1
D-2
D-3
D-4
D-5
D-6
D-7
D-8

Plate 4

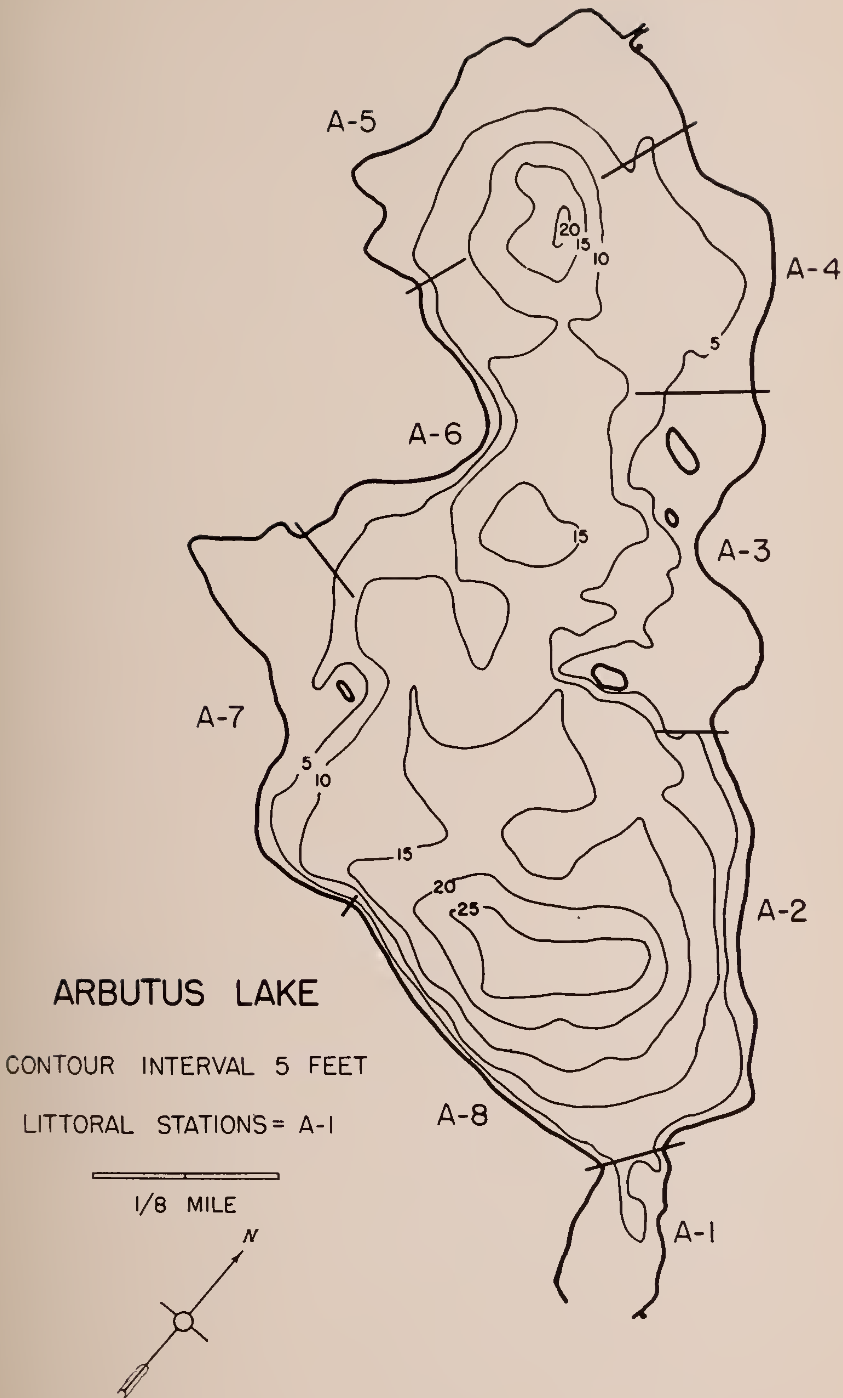
A-5
A-4
A-6
A-3
A-7
A-2
A-8
A-1
20
15
10
5
25
ARBUTUS LAKE
CONTOUR INTERVAL 5 FEET
LITTORAL STATIONS = A-1
1/8 MILE
N

Plate 5